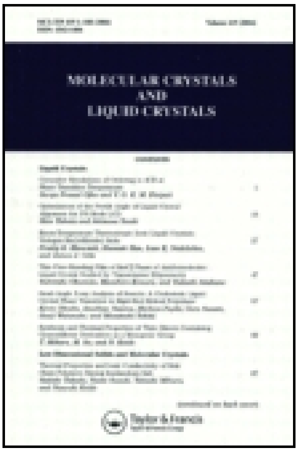

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New Charge-Transporting Fluorinated Materials for Organic Light-Emitting Diodes and Organic Semiconductor Lasers

Masahide Kume [a] , Musubu Ichikawa [a] , Toshiki Koyama [a] & Yoshio Taniguchi [a]

[a] Department of Functional Polymer Science, Faculty of Textile Science and Technology, Shinshu University, Tokita, Ueda, 386-8567, Japan

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New Charge-Transporting Fluorinated Materials for Organic Light-Emitting Diodes and Organic Semiconductor Lasers

MASAHIDE KUME, MUSUBU ICHIKAWA,
TOSHIKI KOYAMA and YOSHIO TANIGUCHI

Department of Functional Polymer Science, Faculty of Textile Science and Technology, Shinshu University, Tokita, Ueda 386-8567, Japan

ABSTRACT

We proposed and synthesized a new oxadiazole derivative, 1,3-bis [2-(3,5-trifluoromethylphenyl)-1,3,5-oxadiazole-5-yl]benzene (F_{12}-OXD). We investigated the characteristics of F_{12}-OXD as an electron transport layer for organic light-emitting diodes (OLEDs) and a cladding layer for organic semiconductor lasers (OSLs). We confirmed that F_{12}-OXD was available for OLEDs and OSLs.

Keywords organic EL; organic light-emitting diode; organic semiconductor lasers; electron transport material; cladding material; fluorinated material; oxadiazole

INTRODUCTION

Significant improvements of organic semiconductor materials for organic light emitting diodes (OLEDs) have been achieved. In particular, large number of electron transport materials have been investigated, because electron drift mobility have been generally low compared with hole drift mobility. The mobility balance between hole and electron is important for efficient electroluminescence (EL) on OLEDs. In this paper, we proposed a new oxadiazole derivative, 1,3-bis[2-(3,5-trifluoromethylphenyl)-1,3,5-oxadiazole-5-yl]benzene (F_{12}-OXD). We investigated suitability for a charge transport material of OLEDs and an optical cladding layer of organic semiconductor lasers (OSLs).

EXPERIMENTAL

We synthesized F_{12}-OXD, which is an oxadiazole derivative having electron withdrawing trifluoromethyl substituents, via a corresponding tetrazole derivative. [1] Chemical structure of F_{12}-OXD is shown in Fig. 1. We measured various physical, chemical, and thermal properties of F_{12}-OXD such as absorption and PL spectra, refractive index, ionization potential, Tg, Tm, and so on by conventional apparatuses. The electron and hole mobility were measured by a time-of-flight (TOF) technique. The sample structure was F_{12}-OXD film (11.0 μm) deposited on an ITO coated glass substrate and counter electrode of Au (15 nm) deposited on F_{12}-OXD. TOF measurements were carried out in atmosphere at room temperature.

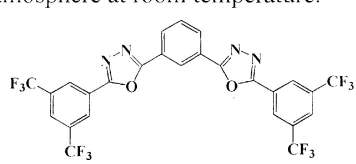

FIGURE 1. Structure of F_{12}-OXD

RESULTS AND DISCUSSION

Table 1 shows various physical, chemical, and thermal properties of

F_{12}-OXD. As shown in the table, F_{12}-OXD was characterized by good thermal stabilities, a low refractive index, a wide band gap, low highest occupied molecular orbital (HOMO) and lowest unoccupied MO (LUMO) levels. The low LUMO level suggests that this compound has a potential for electron transport material (ETM) for OLEDs. The low refractive index and wide band gap are very suitable for cladding layers of OSLs. Figure 2 shows electron and hole mobility of F_{12}-OXD. Compared with Alq as a representative ETM for OLEDs, electron mobility of F_{12}-OXD is approximately tenfold. Furthermore, this compound also shows hole transportability. Thus, F_{12}-OXD is a bipolar transport material.

TABLE 1. Physical and chemical properties of F_{12}-OXD.

λ^{abs}_{max} (nm)	λ^{PL}_{max} (nm)	$RI_{550\,nm}$	HOMO (eV)	LUMO (eV)	Δ (eV)	Tm (℃)	Tg (℃)
280	360	1.52	>6.8	>3.15	3.65	195	135

RI: refractive index, Δ: band gap,
HOMO was larger than upper limit of an apparatus (6.8 eV, Riken AC-1).

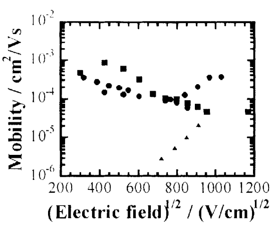

FIGURE 2. Electron(●) and hole(■) mobility of F_{12}-OXD and electron mobility of alq(▲)

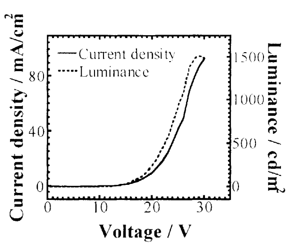

FIGURE 3. *J-V-L* characteristics of OLED with F_{12}-OXD

Figure 3 shows OLED device characteristics of an OLED device having F_{12}-OXD as an electron transport layer (ETL). A structure of the device is ITO/α-NPD(50 nm)/Alq(10 nm)/BCP(10 nm)/F_{12}-OXD(50 nm)/LiF(0.5 nm)/Al. All organics were deposited by vacuum evaporation. As shown in Figure 3, a current density (J) – voltage (V) characteristics of the device was shifted to a high voltage side compared with a conventional ITO/α-NPD/Alq/LiF/Al device. Quantum efficiency of the device was 2.5

cd/A. The high voltage shift of *J-V* characteristics will be caused by non-optimized device structure. However, quantum efficiency of this device was rather high in spite of non-optimized device structure. Since F_{12}-OXD has a high hole blocking ability caused by the deep HOMO level (>6.8 eV) and has good electron mobility, this compound will be well suited for an ETM of OLEDs.

We also investigated suitability as an optical cladding layer of photopumped OSLs. Two different structure devices: glass/laser active layer (LAL, 50nm) and glass/F_{12}-OXD(200 nm)/LAL(50 nm)/F_{12}-OXD(200 nm) were measured. An amplified spontaneous emission (ASE) was not observed in the device without F_{12}-OXD, but an ASE was observed in the F_{12}-OXD device. Thus, F_{12}-OXD has the suitability as an optical cladding layer. The threshold of the ASE was 45.2 kW/cm^2.

CONCLUSION

We proposed and synthesized a new oxadiazole derivative, 1,3-bis[2-(3,5-trifluoromethylphenyl)-1,3,5-oxadiazole-5-yl]benzene (F_{12}-OXD). We investigated the characteristics of F_{12}-OXD as an electron transport layer for OLEDs and a cladding layer for OSLs. We confirmed that F_{12}-OXD was available for OLEDs and OSLs.

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Reference

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